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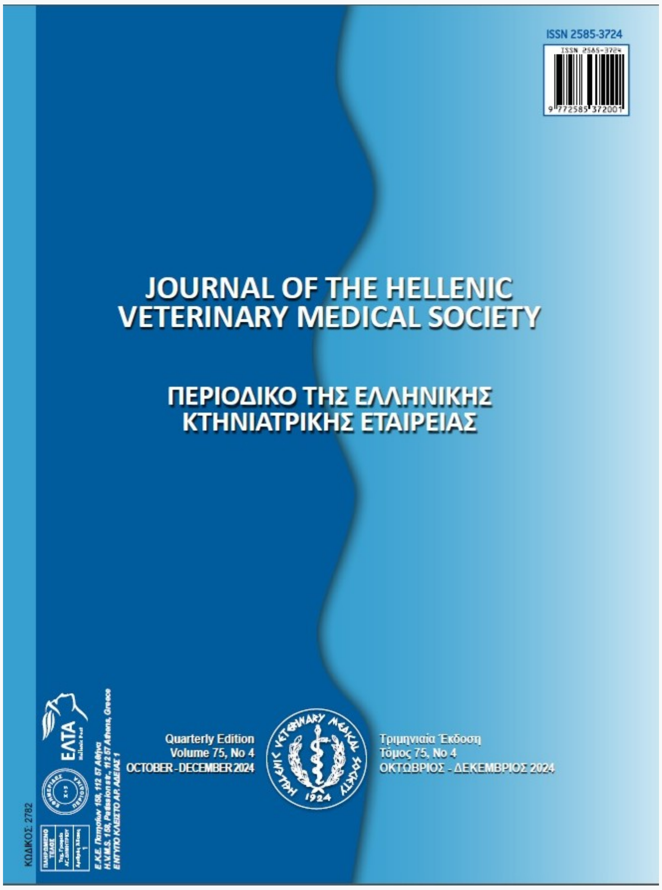

Effect of Moringa oliefera leaves on feed intake, digestibility, milk production and composition in Friesian cows

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Effect of *Moringa oliefera* leaves on feed intake, digestibility, milk production and composition in Friesian cows

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ABSTRACT: A total of 27 healthy Friesian cows with an average of 540±20.5 kg body weight (BW) were used in this study to investigate the effect of *Moringa oleifera* leaves (MOL) on digestibility, feed efficiency, milk production and milk composition. Cows were allocated into three groups: control group (T1) fed basal ration without MOL, low dose MOL-supplemented group (T2) fed basal ration supplemented with 40g MOL /cow/day and high dose MOL-supplemented group (T3) fed basal ration supplemented with 60g MOL /cow/day starting from the 10[th] day to the 180[th] day of postpartum. Average daily feed intake was not significantly changed among the three groups, however, cows in T2 and T3 had significantly (P<0.05) higher digestibility coefficients protein and albumin plasma levels and significantly (P<0.05) lower plasma levels of total lipid, cholesterol and urea-N than cows in T1. In addition, the average daily milk yield, 4% fat-corrected milk yield (FCMY), fat percentage and fat yield in milk were significantly increased in T2 and T3 compared with T1. However, protein, lactose, total solids, and solids not fat in milk were not significantly changed among the three groups. Moreover, cows in T3 had the highest economic efficiency, followed by T2 and T1. It could be concluded that feeding 60 g of MOL to Friesian cows resulted in better digestibility, blood plasma parameters, milk yield and composition, and feed economic efficiency.

***Keywords**: Friesian cows; Moringa oleifera leaves; digestibility; milk yield and composition.*

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INTRODUCTION

Moringa oleifera (MO) is a fast-growing softwood tree that is widespread in the tropics and subtropics and is able to thrive in a variety of climates and soil types (Sultana, 2020). The tropical MO trees can withstand drought of up to six months and thrive in many types of soil (Duke, 2001; Sultana, 2020; Su and Chen, 2020). Reyes-Sánchez *et al*. (2006a) reported that the dry matter (DM) production from MO can reach 2.4 ton/Hectare/year. MOL have 23 - 30% crude protein , minerals (calcium, iron, potassium), and considerable levels of vitamins A, B, and C making them an excellent food source for livestock (Ferreira *et al*., 2008; Sultana, 2020). Protein content in MOL accounts for 47% of rumen bypass protein that can increase the rumen microbial protein synthesis (El-Naggar *et al*., 2017; Su and Chen 2020). This protein also has a good amino acid profile (Ebeid *et al*., 2020). MOL contain antioxidant compounds such as carotenoids and flavonoids as well as protein, iron, calcium, vitamins A and C (Sultana and Anwar, 2008; Azzaz *et al*., 2016; Sultana, 2020). Besides their antioxidant properties and higher nutritional values, MOL had significant impact on livestock production and can enhance animal and poultry nutrition and support immune system (Fahey, 2005; Foidl *et al*., 2001; Sultana *et al*., 2015). Indeed, cows fed diets supplemented with MOL showed significant improvements in food intake, digestibility, and body weight gain (Manaye *et al*., 2009). Because of its high protein content, MOL meal can be utilized as a supplement to boost milk output, milk fat and lactose percentages, and feed efficiency (Kholif *et al*., 2019, 2022). In addition, increased nutritional digestibility, feed consumption, and animal production have all been linked to the inclusion of fresh MO leaves in the diets of goats, sheep, and cows (Sultana *et al*., 2015; kholif *et al*., 2022).

Thus, this study aimed to determine the effect of MOL supplementation on feed efficiency, digestibility, milk output and its composition in Friesian cows.

MATERIALS AND METHODS

This study was conducted at Sakha Animal Production Research Station, Animal Production Research Institute, Agriculture Research Center, Ministry of Agriculture in cooperation with the Department of Animal Production, College of Agriculture, Kafrelshaikh University, Egypt. It was approved by the ethical committee of Kafrelshaikh University (license number, KFS1345/10).

Twenty-seven healthy Friesian cows (40-60 months old, 540±20.5 Kg BW, and 2-3 parities) were enrolled in this study. Cows at the 10^{th} day of postpartum were randomly divided into three groups (n = 9/group): control group (T1) fed basal ration without MOL, low dose MOL-supplemented group (T2) fed basal ration supplemented with 40g MOL /cow/day, and high dose MOL-supplemented group (T3) fed basal ration supplemented with 60g MOL /cow/day starting from the 10^{th} day to the 180^{th} day of postpartum. MOL was obtained from National Research Center, Egypt. MOL contain 4.21% fat, 38.4% protein, 6.5% ash, 31.73% carbohydrate, 7.21% fiber and 11.5% moisture.

The feeding method was performed according to the NRC's (2001) guidelines for dairy cows based on their live body weight and milk production. The bas-

Table (1): Chemical composition of feedstuff and calculated value of experimental rations.

Items	DM %	Composition of DM %					
		OM	CP	CF	EE	NFE	Ash
CFM (T1)	91.31	92.11	16.60	9.86	2.61	63.04	7.89
CFM+40g MOL (T2)	91.34	92.10	17.07	9.88	2.74	62.41	7.90
CFM+60g MOL (T3)	91.36	92.10	17.30	9.89	2.80	62.11	7.90
Fresh barseem (FB)	18.49	86.51	17.20	20.73	3.35	45.23	13.49
Corn silage (CS)	32.85	90.95	9.72	16.88	2.59	61.76	9.05
Rice straw (RS)	90.51	83.61	2.63	32.27	1.42	47.29	16.39
Moringa oleifera (Mol)	92.21	91.89	28.93	10.44	5.92	46.6	8.11
Calculate value							
Control (T1)	61.33	89.37	13.27	17.17	2.65	56.28	10.63
40 g Mol(T2)	61.30	89.36	13.48	17.18	2.66	56.04	10.64
60 g Mol (T3)	61.43	89.36	13.60	17.19	2.67	55.90	10.64

CFM: concentrate feed mixture DM: Dry matter, OM: Organic matter, CP: Crude protein, CF: Crude fiber, EE: Ether extract, and NFE: Nitrogen free extract.

al diet contained concentrates feed mixture (CFM), fresh Berseem (FB), rice straw (RS), and corn silage (CS). According to the A.O.A.C.'s (1995) approved methodology, chemical analysis of typical monthly samples of feedstuffs was performed for CP, CF, EE, NFE, and ash on DM basis (Table 1). The CFM was offered to animals at 8 am and 2 pm. The morning and the evening CFM feeding were followed by FB, CS and RS, respectively.

At the last week of feeding period, digestibility trials in metabolic cages were conducted to determine the digestibility coefficients of various nutrients of the experimental rations using acid insoluble ash as a marker (Abu El-Hamd *et al*., 2015). Feces were collected daily in the last week, then dried, and grounded. Nutritive values in terms of TDN and DCP of different experimental rations were calculated according to the obtained digestibility coefficients. Representative samples from CFM, CS, RS, FB and feces were also taken and prepared for chemical analysis by the methods of A.O.A.C. (1995).

According to the managerial practices applied on the farm, cows were milked twice daily at 6 am and 5 pm by milking machine. Daily milk yield was individually recorded for morning and evening milking starting from 10 days until 180 days of postpartum period. Average monthly milk yield was calculated for each cow. Milk samples were taken monthly for determining milk composition using Milko-Scan (Model 133B).

At the end of the experimental period, blood samples were collected from the jugular vein in clean test tubes containing heparin as anticoagulant factor. Blood plasma was separated by centrifugation of the collected samples at 4000 rpm for 10 min, then plasma was kept frozen at -20°C until chemical analyses. The concentration of proteins, albumin, globulin, glucose, lipids, cholesterol, and urea-N in blood plasma were determined using commercial kits (Diagnostic System Laboratories, Inc USA).

In this experiment each cow within each group was considered as an experimental unit. Shapiro-Wilk's and Levene's tests were used to check the normality and homogeneity of the obtained data, respectively. The obtained results were statistically analyzed according to Snedecor and Cochran (1994) as the following model: $Y_{ij} = U + A_i + e_{ij}$. Where: Y_{ij} = Observed values, U = Overall mean, A_i = Experimental groups and $\mathbf{e}_{ij}$ = Random error**.** Duncan's multiple range test (1955) was used to test the substantial discrepancies between means.

RESULTS AND DISCUSSION

Table (2) displays the daily average feed intake in the experimental groups. The daily average feed consumption of CFM, FB, CS and RS did not differ significantly among the various groups. However, total DM intake was insignificantly reduced, while TDN and DCP intakes were insignificantly increased in T2 and T3 compared with T1. The improvements in TDN and DCP consumption for T2 and T3 may due to the better meal quality and higher levels of moringa, which improve the availability and absorption of vital nutrients, including protein, energy, and minerals found in dietary organic matter. These results agreed with those reported by Sayed-Ahmed and Shaarawy (2019), El-Esawy *et al.* (2018), who reported that daily feed intake was not significantly different among the MO supplemented and non-supplemented groups. Moreover, Nadir *et al*. (2005) found that addition of MO as a protein supplement to poor-quality meals increased DM consumption.

The nutritional values and nutrient digestibility coefficients for various feeds are displayed in Table (3). T2 and T3 exhibited significantly (P<00.05) increased digestibility coefficients of DM, CF, NFE, DCP, OM and CP values relative to T1. However, the digestibility coefficient of EE was significantly higher in T2 and T3 than in T1, the differences between T3 and T1 were not significant. DCP value was insignificantly different among all groups. The DCP value increased in T2 and T3 by 7.21 and 7.65% compared with T1, respectively. The increased digestibility in cows receiving MOL supplements may be a result of the plant's antibacterial and antioxidant properties (Burtis and Bucar, 2000). These variables caused some modifications in the way that digestion worked, which increased the amount of available nutrients and used in the rumen and may had an influence on how well experimental meals were digested and nutrient-dense (El-Esawy *et al*., 2018). Jabeen *et al*. (2008) found that lipophilic substances may be responsible for the antibacterial activities of MO seed extracts. Sayed-Ahmed and Shaarawy (2019) reported that addition moringa as a protein source to diet improves food digestion. Nutritive value and nutrients digestibility improvement with supplementation low level of MOL was consistent with the findings of earlier studies (Parra-Garcia *et al*., 2019; Dhanasekaran *et al*., 2020; Abdel-Raheem and Hassan 2021).

Table (4) displays the results of several blood parameters. Blood plasma concentrations of total protein and albumin were significantly ($P<0.05$) increased in T2 and T3 than in T1, however, total lipid, cholesterol and urea-N concentrations in blood plasma were significantly decreased in T2 and T3 compared with T1. The globulin and glucose concentrations were not significantly changed in the three groups. Similarly, El-Esawy *et al.* (2018) reported that total protein and albumin concentrations significantly increased but, urea-N concentration in plasma significantly decreased after addition of Moringa stems into the ration. The comparison of blood biochemical profile with nutrient intake may reveal the necessity to increase or decrease the consumption of particular nutrients (Animashahun *et al*., 2006). Similar to our findings, cholesterol and triglycerides serum levels reduced after consumption of MO-supplemented food (Babiker *et al*., 2016; Zeng *et al*., 2018; Bashar *et al*., 2020).

Table (5) shows that the average daily milk yield in T3 and T2 (5.13 and 9.17%) and 4% FCMY (16.69 and 22.04%), respectively were significantly higher than in T1. This infers that MOL improves the rumen environment, resulting in higher microbial production, or that MO protein has favorable rumen bypass properties.

Table (2): Average daily feed intake of CFM, FB, CS, and RS offered to cows in the experimental groups.

Items	Experimental groups		
	T1	T2	T3
Concentrate feed mixture (CFM, kg/day)	7.04±0.51	6.86±0.53	6.79±0.51
Fresh Barseem (FB, kg/day)	21.53±1.2	21.10±1.3	20.82±1.2
Corn silage (CS. kg/day)	9.86±0.61	9.59±0.59	9.44±0.56
Rice straw (RS, kg/day)	2.65±0.24	2.57±0.25	2.54±0.22
Total DM intake (kg/day)	16.05±0.5	15.65±0.4	15.45±0.5
TDN intake (kg/day)	10.07±0.4	10.25±0.3	10.27±0.4
DCP intake (kg/day)	1.56±0.2	1.60±0.1	1.61±0.2

T1: control group, T2 and T3: Supplemented with *Moringa oleifera* leaves by 40 and 60 g/cow/day, respectively.

Table (3): Digestibility coefficients and nutritive value of the experimental ration.

Item	Experimental groups		
	T1	T2	T3
Digestibility coefficients (%)			
Dry matter, DM	65.42±0.75^{b}	68.54±0.79^{a}	69.95±0.82^{a}
Organic matter, OM	67.64±1.11^{b}	70.48±1.15^{ab}	71.45±1.04^{a}
Crude protein, CP	73.24±0.75^{b}	75.67±0.86^{ab}	76.51±0.78^{a}
Crude fiber, CF	65.46±1.33^{b}	70.88±1.24^{a}	70.44±1.15^{a}
Ether extract, EE	68.99±1.68^{b}	75.40±1.62^{a}	72.36±1.54^{ab}
Nitrogen free extract, NFE	65.26±0.86^{b}	68.88±0.88^{a}	70.48±0.98^{a}
Nutritive value (%)			
TDN	62.74±0.57^{b}	65.51±0.69^{a}	66.46±0.64^{a}
DCP	9.72±0.74	10.20±0.69	10.41±0.78

T1: control group, T2 and T3: Supplemented with *Moringa oleifera* leaves by 40 and 60 g/cow/day, respectively. $^{a\ and\ b}$: Within the same row, the means are considerably different at ($P<0.05$).

Table (4): Biochemical concentrations in blood plasma of Friesian cows in the experimental groups.

Items	Experimental groups		
	T1	T2	T3
Total protein (g/dl)	7.23±0.19^{b}	7.86±0.13^{a}	7.96±0.09^{a}
Albumin (g/dl)	3.84 ±0.09^{b}	4.12±0.09^{ab}	4.37±0.07^{a}
Globulin (g/dl)	3.38±0.25	3.74±0.08	3.59±0.12
Glucose	52.97±1.25	55.70±0.55	57.27±0.81
Total lipid	234.3±3.36^{a}	193.0±3.60^{b}	191.7±3.82^{b}
Cholesterol	164.7±1.25^{a}	151.0±1.7^{b}	149.0±3.1^{b}
Urea-N	29.67±0.55^{a}	25.57±0.45^{b}	24.4±0.44^{b}

T1: control group, T2 and T3: Supplemented with *Moringa oleifera* leaves by 40 and 60 g/cow/day, respectively. $^{a\ and\ b}$: Within the same row, the means are considerably different at ($P<0.05$).

Table (5): Milk yield and milk constituents of experimental rations.

Items	Experimental groups		
	T1	T2	T3
Milk yield (kg/day)			
Fresh milk yield	20.47±0.31[b]	21.52±0.48[ab]	22.34±0.39[a]
4% FCM yield	17.53±0.53[b]	20.45±0.64[a]	21.39±0.59[a]
Milk fat (F)	0.616±0.07[b]	0.784±0.06[ab]	0.854±0.07[a]
Milk protein (P)	0.653±0.14	0.725±0.13	0.798±0.14
Milk constants %			
Fat	3.04±0.21[b]	3.67±0.24[ab]	3.86±0.22[a]
Protein	3.19±0.12	3.37±0.14	3.56±0.16
Lactose	4.36±0.22	4.60±0.18	4.60±0.25
Solid not fat	8.10±0.58	8.50±0.52	8.83±0.62
Total solid	11.14±0.76	12.59±0.74	12.69±0.84

T1: control group, T2 and T3: Supplemented with *Moringa oleifera* leaves by 40 and 60 g/cow/day, respectively. [a and b:] Within the same row, the means are considerably different at (P<0.05).

The higher milk protein and fat contents following MOL supplementation agree with the findings of ElBadawi *et al*. (2023); Kholif *et al*. (2018). Hence, MO could stimulate the production of acetate which acts for the biosynthesis of fat (Babiker *et al*. 2016); Dong *et al*. (2019); Dhillod *et al*. (2022); Arshad *et al*. (2022) who found that daily milk yield was significantly (P<0.05) increased in lactating cows when fed with diet supplemented with MOL. These results are consistent with Reyes-Sanchez *et al*. (2006 a,b) who found that supplemented MO elevated milk yield due to increased CP intake. Mohamed *et al.* (2014) reported that milk yield was higher 16.00 and 25.40% with rations containing 20 and 40% MO than control group.

Table (5) shows that fat and fat yield were significantly higher in T3 and T2 than in T1. However, protein, lactose, solids not fat and total solids percentages in milk were not significant. The contents of milk tended to increase with increasing the level of MOL with not significant differences. The current findings are consistent with those reported by Reyes-Sanchez *et al*. (2006b) who suggested that cows supplemented with MO had higher levels of milk fat and CP than cows given a control diet. The results agree with Khalel *et al*. (2014); Imran *et al*. (2016); Tadeo *et al.* (2019); Dhillod *et al*. (2022); Kekana *et al*. (2020) found increased milk protein and fat contents after addition of MO to dairy cows' ration. Dhillod *et al.* (2022) found a significantly higher milk lactose (%) in milk of buffalo fed ration supplemented with MO than the control group. Similarly, Tadeo *et al*. (2019); Choudhary *et al*. (2018) reported that inclusion of MOL in concentrate mixture increased milk lactose level. Moreover, milk yield and composition in ewes and buffaloes, were also improved following addition of MO to diet (Aguirre *et al*., 2020; Arshad *et al*., 2022). The MO has high contents of secondary bioactive antibacterial, anti-inflammatory, and antioxidant compounds benefited ruminant feed utilization, milk production, and composition at various levels (Khalel *et al*., 2014; Kholif *et al*., 2016; Dong *et al*., 2019; Kekana *et al*., 2020, 2021). Additionally, Nadir *et al*. (2005) demonstrated that adding Moringa as a protein supplement to meals enhanced DM consumption and boosted milk production without changing the composition of the milk. Positive benefits on goat eating behaviour (Manh *et al*., 2005) and sheep growth rate (Ben Salem and Makkar, 2009) may due to the inclusion of MO in their diets. Reyes-Sánchez *et al*. (2006b) found that addition of both fresh MO or using MOL as a protein source in concentrate ration of dairy cows had positive effects on animal production.

Table (6) shows the feed efficiency represented as the quantities of DM, TDN, and DCP per 1 kg 4% FCMY as impacted by the number of MOL. The quantity of DM and TDN per 1 kg of 4% FCMY significantly reduced following the addition of MOL (8.40, 7.79 and 14.29, 14.29%) for T2 and T3, respectively, as compared with T1. However, there were no appreciable variations between the various groups in terms of the quantities of CP and DCP per 1 kg 4% FCMY as supplementation tended to lower it. The increases in nutritional digestibility (Table 3), feed intake (Table 2), and milk output may be responsible for the feed conversion ratio improvements with MO leaves (Table 4). These findings are consistent with those of El-Esawy *et al*. (2018) and Sayed-Ahmed

Table (6): Feed and economic efficiency of the experimental groups in cows.

Items	Experimental groups		
	T1	T2	T3
Feed efficiency			
Kg 4% FCMY /kg DM	0.78±0.05^{b}	0.93±0.05^{ab}	0.99±0.06^{a}
Kg 4% FCMY/kg TDN	1.24±0.06^{b}	1.43±0.05^{a}	1.49±0.07^{a}
Kg 4% FCMY/kg DCP	8.03±0.22^{b}	9.13±0.24^{a}	9.49±0.26^{a}
Economic evaluation			
Daily feeding cost, L.E.	74.27±0.48^{b}	72.50±0.52^{ab}	71.75±0.70^{a}
Price the daily fresh milk yield L.E.	122.82±2.6^{b}	129.12±2.9^{ab}	134.04±3.1^{a}
Revenue of feeding cost L.E.	47.80±3.1^{b}	56.62±3.3^{ab}	62.29±3.5^{a}
Relative economic efficiency%	100	118.45	130.31

Kg 4% FCM /kg DM = kg 4% FCMY- kg DM intake, Kg 4% FCM/kg TDN = kg 4% FCMY- kg TDN intake and Kg 4% FCM/kg DCP = kg 4% FCMY- kg DCP intake.

$^{a\ and\ b}$: Within the same row, the means are considerably different at (P<0.05).

Prices of one kg were 8.0 LE for concentrate feed mixture, 0.52 LE for fresh berseem, 0.55 LE for corn silage, 0.50 LE for rice straw, 2.25 LE for moringa stems and 6.0 LE for milk according to prices 2021.

and Shaarawy (2019) who reported that feed efficiency was better for lambs fed rations containing 25% MO stems in replacement to clover hay and concentrate feed mixture compared with the control ration due to the beneficial effects of MO providing stimulator factors and essential nutrients, especially protein, energy, minerals, and vitamins. Kholif *et al*. (2022) found that MO treatments increased feed efficiency compared with the control groups.

Data of economic efficiency in Table (6) showed that MOL supplementation resulted in significant improvements in economic efficiency. Average daily feed cost and feed cost per kg milk yield significantly lowered, however, the price of milk production and economic efficiency was significantly higher in MOL-supplemented groups with better results in T3 followed by T2 than T1.

CONCLUSION

Adding MOL to the diet of Friesian cows increased digestibility, blood plasma parameters, milk output and its composition, and higher feed economic efficiency, the best results were obtained from adding 60g MOL to cattle ration.

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CONFLICT OF INTEREST

None declared

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